

**Independent peer review of the  
stock assessment of walleye pollock  
in the eastern Bering Sea**

**May 16–19, 2016  
Seattle, Washington**

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***For The Center for Independent Experts (CIE)*  
July 2016**

## Executive summary

During 16-19 May 2016, the stock assessment of Eastern Bering Sea (EBS) pollock was reviewed at Alaska Fisheries Science Center (AFSC) in Seattle, Washington. EBS pollock is a major commercial fishery supplying a substantial proportion of the global white fish market. I was one of three Center for Independent Experts (CIE) reviewers tasked with reviewing the stock assessment.

There are four main sources of data available to the assessment model: The catch history, commercial catch sampling (age frequencies and annual mean weight-at-age), a bottom trawl time series, and an acoustic survey time series. In addition, there is a short, but early, CPUE index, and a more recent acoustic times series collected during the bottom trawl survey (backscatter only).

The data collected in support of the EBS pollock stock assessment are exceptional in terms of quantity and of very good quality. The protocols for catch sampling and ageing appear to be very good. The bottom trawl survey provides a long and consistent times series, but it should be analyzed to see if vessel effects are present. The acoustic survey data, from the mid-1990s onwards, should be reanalyzed to provide pollock estimates for most of the water column (not cut off at 3 m above the seabed). It may be possible, after an analysis of mark types to improve the design of the acoustic survey with regard to targeted trawling.

The current stock assessment model fails to adequately capture uncertainty and does not represent the best available science. Natural mortality is assumed known exactly despite being quite uncertain. Similarly, the stock recruitment relationship is very uncertain and although it is estimated it is done so with an artificial and very constraining prior. Also, the uncertain future fishery selectivity is not properly modelled. A well-estimated average is used, whereas a random choice of previous estimated selectivities could be modelled. The pdf of  $F_{MSY}$  is not well determined as  $F_{MSY}$  depends strongly on the stock recruitment relationship, fishery selectivity, and natural mortality.

The stock assessment model is not as technically sound as it could be, and is in need of improvement and refinement. This should be done over the next few years. I suggest that the current approach be continued (with some improvements) and that an alternative technically correct Bayesian model be developed with a view to replacing the existing model. Ultimately, a multi-species trophic interaction model may be used for stock assessment, but this should wait until an improved single-species stock assessment model is fully implemented. At that stage, the trophic interaction model and the single-species model could be tested (using an operating model) to see which is likely to provide better stock assessment estimates.

## **Background**

From 16-19 May 2016, the stock assessment of EBS pollock was reviewed at AFSC in Seattle, Washington. EBS pollock is a major commercial fishery supplying a substantial proportion of the global white fish market. The assessment model is implemented as purpose written code in ADMB (Fournier 2015).

I was one of three CIE reviewers. The meeting was chaired by Dr. Anne Hollowed from AFSC and the stock assessment modelling presentations were made by Dr. Jim Ianelli (*see* Appendix 3 for a full list of participants). This report presents my review findings and recommendations in accordance with the Terms of Reference for the review (*see* Appendix 2, annex 2). A summary report was not produced for the meeting.

## **Review Activities**

### ***Pre-meeting***

Meeting documents and materials were made available in electronic form in advance of the meeting (*see* Appendix 1). I familiarized myself with the background material and read the main data and assessment documents in detail prior to the meeting.

### ***Meeting***

The first two days of the meeting consisted primarily of presentations as detailed in the agenda (Appendix 2, annex 3). The last two days were more informal with the results of requests being presented and clarification of previous issues being obtained. Early on the first day I asked if a summary report was to be produced for the meeting and the Chair informed us that it was not necessary.

The details of the observer program, trawl surveys, and acoustic surveys were presented to the meeting. I pointed out the problem that I had previously identified with regard to pollock acoustic surveys (during the Gulf of Alaska pollock review, *see* Cordue 2012). The acoustic data are used to provide estimates of numbers at age, but this is problematic (details of this issue are discussed later in the report).

Ageing of pollock was described. A “mixed” method is used whereby a reader may elect to count the rings using just a surface reading or, more typically, the otolith is “broken and burnt”. We were told that from experience it had been noted that when the surface rings were clear that the same count was always obtained if the otolith was subsequently broken and burnt. I did request documentation supporting this claim, but was told that it probably hadn’t been documented. The reading protocols seemed excellent, but this aspect should to be checked and documented.

Ecosystem considerations were apparent from the first day. It was noted that salmon bycatch was closely monitored in the pollock fishery and if it got too high some sectors of the fishery could be closed. Also, because pollock are prey of Steller sea lions, the

pollock control rule would close the fishery if biomass dropped below 20%  $B_0$ . There was also a presentation on the CEATTLE multi-species model which may be used for stock assessment of pollock in the future. For the moment it is probably better to focus its use on management strategy evaluation (while a single species pollock stock assessment model is refined).

The stock assessment model was described in two stages. Initially, the results of the 2015 assessment were presented in detail. Then further details of model structure were discussed. I requested a model run where natural mortality was estimated rather than fixed. Mr. Francis made a number of requests, mainly to do with data weighting issues.

One of the unusual features of the model, that was discussed at some length, was allowing an almost unparameterized fishery selectivity to change from year to year with very little restriction. That is, the selectivity at each age for each year was estimated with little constraint (it was a random walk with the five oldest ages forced to be equal within each year). This enabled the catch-at-age to be fitted almost exactly since the early 1990s (when high effective sample sizes were used in the model). There is no doubt that the catch sampling of this fishery is superb but, as I pointed out, to assume that the catch at age is known exactly, combined with fixed natural mortality, means that the assessment is essentially a VPA.

During the presentation of the 2015 assessment results, where the inclusion in the model of annual mean weights-at-age was explained, Dr. Sparholt asked why the mean weights-at-age for 2015 were so low (compared to 2014). I then noticed that for almost every cohort the mean weight-at-age in 2015 was lower than it was in 2014 despite the fish having aged a year (*see* Table 1.16 in the pollock SAFE chapter). This shrinkage of the fish was not present in the historical results, and it was surmised by meeting participants that the year effect in 2014 had been strong (supporting high mean weights-at-age) and that the absence of a year effect in 2015 meant that the fish weights had dropped causing the shrinkage. At the end of the meeting I asked if Dr. Sparholt had been the first to notice the “shrinking fish” and I was told that the SSC had discussed the issue. However, the 2015 assessment was accepted by the SSC and there was no mention of the erroneous mean weights-at-age in the SSC meeting minutes (*see* December 2015 minutes) or indeed the Plan Team meeting minutes (*see* November 2015 minutes).

### ***Post-meeting***

As it had been agreed that a summary report was not needed, there was no need for any post-meeting collaboration between the CIE reviewers or the meeting chair. I returned to New Zealand and, when suitably recovered from the travel, drafted my report.

## Summary of findings

Each of the Terms of Reference are considered below.

1. *Evaluation, findings, and recommendations on quality of input data and methods used to process them for inclusion in the assessment. In particular:*
  - *Is the use of the index of acoustic backscatter from opportunistic (AVO) used appropriately?*
  - *Is modeling observed numbers from surveys appropriate?*
  - *How should data on mean body mass at age be best used for model projections?*
  - *How should the various data sets be weighted?*

The four bullet points will be addressed below after the context is provided by a discussion of the main data sets. Various recommendations will be noted in bold (these are collected together at the end of the report).

### Observer sampling

Since the early 1990s, the observer coverage for this fishery has been superb with vast numbers of length frequencies and large numbers of otoliths (used in three age length keys each year). The observer manual outlines sound strategies for taking random samples at sea and on shore. If the manual is always followed, then the length frequency of the catch is very well determined each year.

### Catch-at-age from the fishery

The stock assessment model fits to proportions-at-age from the fishery. The ageing protocols appear sound except that there should be a check that surface-read otoliths really are being read accurately (e.g., **perhaps 1 in 10 of such otoliths should be broken and burnt to confirm that the same reading is obtained**). Ageing error is estimated from multiple readings of the same otoliths and the error matrix is used by the model when generating predicted values.

The proportions-at-age cannot be as well estimated as the length frequencies. The age readings may be subject to bias and the ageing error matrix is only an approximation. Intuitively it seems clear that the stock assessment model should not be fitting catch-at-age almost exactly.

### Trawl survey

There is a consistent annual summer trawl survey time series starting in 1982, which is used to provide relative abundance indices for EBS pollock together with proportions-at-age (e.g. Lauth and Nichol, 2013). The survey is multi-vessel with the same trawl gear and protocols maintained (as well as possible) throughout the duration of the time series. Historically, the survey was said to index pollock within 3 m of the seabed and the

summer acoustic survey (see below) was used to index pollock that were more than 3 m above the seabed. The idea was that the estimates from the trawl survey and acoustic survey could be added together to provide full coverage of pollock. This assumes that each index is absolute and that the 3 m cutoff is real (i.e., no vertical herding of pollock). The current view is that vertical herding of pollock does occur (Kotwicki et al. 2013, 2015). And, of course, the indices are not absolute.

A potential weakness of the trawl time series is that different vessels, despite using the same gear and protocols, may have different catching efficiencies for pollock. As the usual practice is for the two vessels being used each year to occupy stations in a similar region at a similar time, it may be that the existing data would be adequate for estimating vessel effects (with regard to pollock catch rates). Of course, if there are periods in the time series where both vessels are replaced by new vessels in the same year, then vessel and year effects will be confounded. This may or may not be the case. **Certainly it would be prudent to investigate the time series to see if vessel effects can be estimated (using a multiple regression with other explanatory variables, e.g., year, stratum, time-of-day, “weather conditions”).**

#### **Acoustic survey**

A summer acoustic survey is used to estimate an abundance index and proportions-at-age for pollock higher than 3 m off the seabed. The 3 m cutoff is a relic of the historical approach of adding together the trawl and acoustic indices. The acoustic data (from the mid-1990s) can apparently be easily reprocessed to produce estimates for the whole water column (excluding near surface and the shadow zone of about 0.5 m). This new approach, which was outlined at the meeting by Dr. Wilson, can use the bottom trawl species mix (from tows relatively close in time and space to the acoustic transects) with backscatter from bottom layers to estimate the full pollock biomass. **The 3 m cutoff for the acoustic survey should be dispensed with and pollock biomass should be estimated over most of the water column.**

However, there are a number of issues with regard to the analysis and use of the acoustic data. The survey design has a number of parallel transects with a random start point. As pollock marks are seen trawls are periodically targeted on the marks (especially the dense marks). Length frequencies and otoliths are taken from the trawl catches. There is a post-stratification where marks are grouped geographically into a number of length strata. The mean weight and mean backscattering cross section are calculated for each length stratum and applied to the backscatter to produce estimates of numbers-at-age, total numbers, and biomass (e.g., Honkalehto and McCarthy, 2015)

This approach is probably adequate to produce total biomass estimates as errors in length frequency estimation will, to some extent, cancel out when biomass is calculated (that is, the ratio of mean weight to mean backscattering cross section may be fairly constant over a good part of the length range – more so if 1 year olds are in separate marks).

The accurate estimation of numbers-at-age requires that the length frequency samples are representative of the pollock within each length stratum. In the current analysis, each length frequency is converted to a density and each density is given equal weight within the length stratum. Equal weights are unlikely to be appropriate. This was discussed in

some detail in my review of the Gulf of Alaska pollock and examples were given illustrating that there can be substantial biases using this approach (*see* Cordue 2012).

There is also the issue that the selectivity of the ensonified pollock is not the selectivity associated with the estimated numbers-at-age from the acoustic survey. The trawl gear has net selection (tending to catch fewer smaller fish) and the choice of which marks to target and how to tow (e.g., top of the mark, bottom of the mark, bottom gear or midwater gear) may also introduce a selection pattern.

There was a good attempt to try to estimate realistic levels of precision for the acoustic indices where multiple sources of bias and variance were included (Woillez et al. 2016). However, the issue of weighting the length frequencies and errors associated with the post-stratification of length strata were not adequately dealt with. I think that a realistic 3-dimensional operating model would be needed to fully capture all the sources of error. However, I would not recommend such an undertaking. I think it should just be noted that the errors are substantial and that an approximate starting point (e.g., CV = 30% for biomass with low effective  $N_s$  for proportions-at-age) when fitting the data in the stock assessment model is adequate provided that process error is also estimated in the model (once the model has been refined).

**I recommend that an analysis of mark types be undertaken to better understand the length/age composition of pollock marks. If there is a pre-defined set of mark types, together with an understanding of their properties, then this opens up the possibility of a formal random design with regard to the targeted trawling to obtain length and age composition.** Certainly, it is worthwhile to at least document the different mark types and what is known about their composition.

- *Is the use of the index of acoustic backscatter from opportunistic (AVO) used appropriately?*

#### **AVO time series**

Acoustic data are collected opportunistically during the summer survey from calibrated echo-sounders (Honkalehto et al. 2014). The backscatter (from 3 m above the seafloor) is not corrected for size composition and the index is assumed to be proportional to (acoustic selected) biomass. This is equivalent to assuming that the ratio of mean weight to mean backscattering cross section is fairly constant over the vulnerable size range. The correlation between the AVO index and the summer acoustic index is very good.

On theoretical grounds, this index should contain more error than the summer acoustic index (no corrections for size composition). However, given the good correlation with the summer acoustic index, it is very tempting to include it in the stock assessment model since it is available every year (rather than every two years). **It may not be appropriate to include it in the base model. It should certainly be included in a sensitivity analysis.**

- *Is modeling observed numbers from surveys appropriate?*

The trawl survey index is fitted as total numbers and proportions-at-age. **It is probably better to fit to total biomass rather than total numbers.** This is because the total biomass index can be derived from just the catch weights on each tow rather than using extra calculations to estimate total numbers on each tow. To form the model predictions of the total biomass index mean weights-at-age for the survey are required, but these are available.

For the acoustic survey the numbers at age 1 are fitted as a time series with total numbers from age 2 and older as another index with the proportions-at-age (for 2 years and older). It is wise to model the 1 year olds separately, as they could be very poorly estimated as their target strength is not well known and they could be very hit and miss with the trawling. **For ages 2 years and older it is better to fit to total biomass rather than total numbers.** As explained earlier, the ratio of mean weight to mean backscattering cross section could be relatively constant so that biomass estimates are stable to errors in length frequency; whereas estimated numbers will not be. This conclusion is supported by the analysis which attempted to obtain realistic estimates of precision (Woillez et al. 2016).

- *How should data on mean body mass at age be best used for model projections?*

The attempt in 2015 to include uncertainty in projected mean weight-at-age was partially successful. Additional uncertainty was propagated into the pdf for  $F_{MSY}$  which resulted in a larger buffer between the OFL and the maximum ABC than in the 2014 assessment (*see* pollock chapter in the 2015 SAFE). However, the shrinkage of the fish within each cohort from 2014 to 2015 was an unfortunate error. It resulted in an underestimation of the OFL and the maximum ABC. The magnitude of the error is undocumented at this stage. There is a figure in the SAFE which shows the direction of the error but gives no clue as to its absolute size (*see* the uncaptioned figure on page 66 in the 2015 SAFE).

**The shrinkage should not be allowed to occur and this may be best achieved by modelling increments in mean fish weight rather than the mean weights.**

- *How should the various data sets be weighted?*

Prior to being used in the stock assessment, the observation error associated with each data set should be estimated as well as possible – and this seems to have been done reasonably well (e.g., bootstrapping of catch-at-age data). However, as is currently done (although not ever year) additional weighting needs to be done in the stock assessment model to allow for process error (e.g., the method(s) of Francis 2011). In the current stock assessment model, there are some difficulties with the parameterisation of fishing selectivities. A glance at the catch-at-age fits from the early 1990s onwards (where effective sample sizes are about 300) show an almost exact fit. This implies almost no error, which is inconsistent with the process error that must be present due to less than



perfect ageing (e.g., ageing error matrix not known perfectly; possibility of readers putting otoliths in a known strong cohort when in doubt). **The methods of Francis (2011) cannot be properly applied until the fishery selectivity is properly constrained.** Also, the iterative reweighting of the catch-at-age should not be done over the whole time series. It will need to be split into three time periods (the two that were used for assigning low effective sample sizes before the early 1990s, and then the latter period).

2. *Evaluate and provide recommendations on model structure, assumptions, and estimation procedures uses to assess stock status and condition. In particular:*

- *Are the selectivity approaches used for surveys and fishery appropriate?*
- *How should trans-boundary aspects of the resource be handled?*
- *What constraints, if any, should be placed on survey catchability?*
- *How should model projection alternatives be evaluated/presented?*
- *Anything else on which the reviewers care to comment.*

As for TOR 1, the context will be provided before each bullet point is considered.

Structurally the model is quite simple with a single area and a single fishery. There is a sub-model for the (Ricker) stock-recruitment relationship where a steepness parameter ( $h$ ) is estimated together with  $R_0$  (consistent with estimated recruitment from 1978 onwards). The Baranov catch equation is used and fishery selectivity is estimated (almost) for each age and each year.

Estimation is done using a quasi-likelihood approach where an objective function is minimized to find the point estimates and confidence/credibility intervals are generated using a multivariate normal assumption. In the main, likelihoods are generated from distributional assumptions for the data (e.g., lognormal abundance indices, multinomial composition data). However, the likelihood component in the sub-model is derived by assuming that the estimated cohort numbers are lognormally distributed with means predicted functionally from the female spawning biomass in each year. From a statistical point of view, this is hard to justify as likelihood components must be derived from data, not model estimates. It is also an unnecessary approach. **The objective function, for a Bayesian stock assessment, can and should be derived purely from likelihood components (generated by statistical assumptions with regard to data), prior distributions and an occasional penalty function (if absolutely necessary).**

The very free fishing selectivity has already been noted. It is not justified by the quantity and quality of the catch-at-age data as it makes no allowance for process error which must exist. It also creates problems in terms of predicting future selectivity (also in the year of the assessment because catch-at-age data are not yet available). The current approach is to use the average selectivity (in some sense) from the last 6 years. This is problematic for two reasons. The average selectivity from the last 6 years will often look

nothing like the estimated selectivity for any of the individual years. The selectivities in future years may turn out like one of the previous 6 years but they won't look like the average. Also, by using an average selectivity the uncertainty in future selectivities will be underestimated. As an average, the future selectivity is much more well estimated than any single selectivity (so the uncertainty associated with an unknown future selectivity is badly underestimated).

One method to include the uncertainty associated with an unknown future selectivity is to run the model with each of the candidate selectivities (e.g., one of the last 6) and record the mean and variance of each of the quantities of interest (e.g.,  $F_{MSY}$ , beginning of year vulnerable biomass,  $B_{beg}$ ). Then the mean and variance for each quantity of interest can be calculated for a random selection of the selectivity.

For example, assume we have  $Y_1, \dots, Y_n$  with means  $m_i$  and variances  $v_i$ . Form the random variable  $X$  by selecting one of the  $Y_i$  at random with respective probabilities  $p_i$ . Then, using conditional probability, it can be shown that:

$$E(X) = \sum_{i=1}^n p_i m_i$$

and

$$\text{Var}(X) = \sum_{i=1}^n p_i (v_i + m_i^2) - \left( \sum_{i=1}^n p_i m_i \right)^2$$

If it was thought that each of the last 6 selectivities were equally likely, then each  $p_i = 1/6$ . The weighted mean and expanded variance (using the formulae above) for  $F_{MSY}$  and  $B_{beg}$  could be fed into the OFL and maximum ABC calculations **to better capture the uncertainty associated with unknown future selectivities**.

Of course, there are other uncertainties that are not well captured in the current approach. Natural mortality ( $M$ ) is assumed to be 0.9 at age 1 year, 0.6 at age 2 years, and 0.3 for all older ages. These values were estimated many years ago and have occasionally been checked by the current assessment scientist by estimating  $M$  from time to time. The values were found to be consistent with the current model in years past. However, when the age 3+  $M$  was estimated during the review, the point estimate was 0.18. It was thought this estimate may be due to a recent strong cohort which shows little sign of dying. Whatever the reason **there is clearly some uncertainty associated with  $M$  and this uncertainty needs to be propagated through into the pdf of  $F_{MSY}$  and other quantities of interest**.

The stock-recruitment relationship must also be considered uncertain. A parameter associated with the steepness ( $h$ ) of the Ricker stock-recruitment relationship is estimated, but it is done so with a highly restrictive prior which appears arbitrary other than in its ability to limit the estimated productivity of the stock (i.e., without the prior, the stock-recruitment relationship is estimated to be more domed and the stock much more productive). As for  $M$ , **the uncertainty associated with the stock-recruitment**

**relationship needs to be propagated through into the pdf of  $F_{MSY}$  and other quantities of interest.**

- *Are the selectivity approaches used for surveys and fishery appropriate?*

The selectivities for the surveys are parameterized and annual changes are much more restrictive than for the fishery. There may be some annual changes for the surveys with changes in vertical and/or areal availability driven by environmental conditions. If some understanding of these drivers were possible, then an environmental index or two could be used to drive changes in selectivity parameters for the surveys. Otherwise, a constrained random walk may be the best option.

For the fishery, the current formulation is not constrained enough. A short term fix might be to tighten the random walk and the parameterization. In the medium term, I recommend modelling the fishery in much more detail. Certainly the assumption of a constant  $F$  during the year is at odds with two discrete fishing seasons separated by periods with no fishing. It may be that many of the apparent selectivity changes are simply a product of changes in the proportion of fishing effort within structurally different components of the overall fishery. There have also been changes over time in fleet composition, gears used (more bottom trawling in the past), and desired products (surimi, head and gut, fillet, roe). As with the surveys, changes in fish distribution, driven by environmental variables may also have had an effect on fishery selectivity. **A detailed historical analysis of the length/age composition of the catch in relationship to possible explanatory variables is needed to enable the fishery to be split into multiple components for the purposes of stock assessment. The minimum split will be into A and B seasons with a processor and catcher fleet to mimic the reality of the fishery.**

- *How should trans-boundary aspects of the resource be handled?*

Currently the Russian data are ignored in the base model. Given the patchy nature of the data and the uncertainty that it relates to the EBS stock, I think this is an acceptable approach. Other aspects of “trans-boundary” perhaps relate to stock structure. This is almost always a difficult issue and the current approach seems satisfactory given the available information and hypotheses on stock structure.

- *What constraints, if any, should be placed on survey catchability?*

**The information that is known about the survey  $q_s$  should be included in the stock assessment model through informed priors.** For the acoustic survey the main component of the informed prior on the  $q$  is the potential bias introduced by the length-target strength relationship. The same relationship is necessarily used for all points in the time series, and so it potentially introduces a systematic error that can cause  $q$  to deviate from 1 in either direction (it causes an unknown bias). It should not be included in the CVs of the individual points. Other components probably needed in the prior are vertical availability and areal availability. The CV of the prior will be driven by how well the

length-target strength relationship is estimated (not very well currently – see Traynor 1996). **More *in situ* target strength data are needed for pollock to define the relationship (including the slope that should not be assumed to equal 20).**

For the prior on the trawl survey  $q$  there are three components: areal and vertical availability and vulnerability. Bounds can be put on each of these components and an overall range defined. Then a distributional assumption can be made to define a prior (e.g., lognormal with the range being 99% of the distribution; or double lognormal if the shape needs to be more complex).

- *How should model projection alternatives be evaluated/presented?*

The uncertainty associated with future biomass levels relative to reference points is best captured by a full Bayesian analysis which allows the estimation uncertainty associated with all parameters to be captured together with uncertainty over future recruitment. The current approach only includes future recruitment uncertainty. The presentation of the results, even without the full levels of uncertainty, is best presented as a risk analysis (as the assessment author did some years ago). It is useful to present estimates of the probability of “bad things” happening. For example, the probability of SSB falling below  $20\%B_0$  or  $30\%B_0$ ; or the salmon bycatch exceeding the allowed level.

- *Anything else on which the reviewers care to comment.*

The likelihood used for the acoustic and trawl survey abundance time series is not the most appropriate. The surveys are designed so that the expected value of each index is proportional to the survey  $q$  multiplied by the true abundance (or biomass).

That is,  $X_i = qN_i\epsilon_i$  where  $E(X_i) = qN_i$ . This implies that  $E(\epsilon_i) = 1$ , so that if lognormal errors are assumed, then  $\log(\epsilon_i) \sim N(-\sigma^2/2, \sigma)$  rather than  $\log(\epsilon_i) \sim N(0, \sigma)$  as is currently assumed. The details of the correct likelihood and the equation for calculating the  $q$  that minimizes the likelihood can be found in the CASAL manual (Bull et al. 2012).

Finally, the documentation of the current stock assessment model needs to be tightened. There were several instances during the review when the documentation was found to be somewhat at odds with what was actually done. I also noted that all parentheses were missing from the model equations in the 2015 SAFE appendix (square and curly brackets were present, but parentheses were missing).

3. *Evaluate and provide recommendations on harvest recommendations provided by the NPFMC Tier system in the context of the 2,000,000 t BSAI cap and realized management recommendations.*

I have little to offer on this TOR. I am already on record as noting that the NPFMC has a very conservative approach to fisheries management with multiple layers of conservatism (Cordue 2006). I understand that the 2 million t cap generally comes into effect and as a

consequence the EBS pollock TAC is typically below the recommended ABC. As a stock assessment scientist, this causes me no concern at all and I will not comment further on management choices.

4. *Evaluate the extent that ecosystem data are presently included in the assessment and recommend how and where improvements can be made.*

Ecosystem data are not used in the stock assessment model, but ecosystem data are extensively considered in the stock assessment document and play a role in the choice of recommended ABC and the wider management system. There appears to be an intent to move towards the use of multi-species models (including trophic interactions) for stock assessment at some stage in the future. I would suggest this happen later rather than sooner. I think that for pollock, in particular, being such a major component of the BS ecosystem that a single-species stock assessment model is still the best choice in terms of the bias-variance tradeoff. The use of a trophic interaction model, while allowing a more realistic representation of the ecosystem, will not necessarily provide better estimates of pollock biomass and stock status.

Therefore, I think that the current use of ecosystem data is appropriate. **I recommend that a single-species stock assessment model be used for some years before there is a move to a trophic interaction model.**

### **Critique of the NMFS review process**

The NPFMC have regular reviews of various aspects of their stock assessment processes. This is in contrast to other jurisdictions where particular stock assessments are reviewed as part of the stock assessment process (e.g., STAR Panels). The NPFMC approach has the merit of reducing the pressure on all participants in the review as the success or failure of a particular assessment is not at stake. It has the disadvantage that there isn't independent peer review of a particular assessment in a given year. Rather, the focus of the review is on the methods that have been used (which is also perhaps a good thing).

The EBS pollock stock assessment was last reviewed in 2010, and the reviewers' reports were made available to this panel. However, there was no documentation supplied on how the assessment scientist, the Plan Team, or the SSC reacted and responded to the reviewers' recommendations. **To get the most out of a review it is important that there is a written response to reviewers' recommendations.** This ensures that the recommendations are given due consideration and will also be of benefit to future review panels.

## Conclusions and Recommendations

The data collected in support of the EBS pollock stock assessment are exceptional in terms of quantity and of very good quality. The protocols for catch sampling and ageing appear to be very good. The bottom trawl survey provides a long and consistent times series, but it should be analyzed to see if vessel effects are present. The acoustic survey data, from the mid-1990s onwards, should be reanalyzed to provide pollock estimates for most of the water column (not cut off at 3 m above the seabed). It may be possible, after an analysis of mark types to improve the design of the acoustic survey with regard to targeted trawling.

The stock assessment model is in need of improvement and refinement. This should be done over the next few years. I suggest that the current approach be continued (with some improvements) and that an alternative technically correct Bayesian model be developed in parallel with a view to replacing the existing model. Ultimately, a multi-species trophic interaction model may be used for stock assessment, but this should wait until an improved single-species stock assessment model is fully implemented. At that stage, the trophic interaction model and the single-species model can be tested (using an operating model) to see which is likely to provide better stock assessment estimates.

My recommendations with regard to ageing and fishery independent surveys are:

- Ageing: perhaps 1 in 10 of surface-read otoliths should be broken and burnt to confirm that the same reading is obtained.
- Investigate the trawl survey time series to see if vessel effects can be estimated (using a multiple regression with other explanatory variables, e.g., year, stratum, time-of-day, “weather conditions”).
- Acoustic data:
  - The 3 m cutoff for the acoustic survey should be dispensed with and pollock biomass should be estimated over most of the water column.
  - An analysis of mark types should be undertaken to better understand the length/age composition of pollock marks (which could perhaps lead to a better survey design).
  - More *in situ* target strength data should be collected for pollock to better define the length-target strength relationship.
- It may not be appropriate to include the AVO index in the base model but it should certainly be included in a sensitivity.

For the current stock assessment model (changes progressively made over the next two years):

- It is probably better to fit to total biomass rather than total numbers for the trawl survey.
- For ages 2 years and older, it is better to fit to total biomass rather than total numbers for the acoustic survey.
- Annual mean weight-at-age: the shrinkage of fish should not be allowed to occur, and this may be best achieved by modelling increments in mean fish weight rather than the mean weights.

- Tighten the random walk and the parameterization on the fishery selectivities and then apply the data weighting methods of Francis (2011).
- Incorporate the uncertainty associated with unknown future selectivities into the pdfs of quantities of interest (e.g.,  $F_{MSY}$ ).
- There is clearly some uncertainty associated with  $M$  and this needs to be propagated through into the pdf of  $F_{MSY}$  and other quantities of interest (i.e., estimate  $M$ ).
- The uncertainty associated with the stock-recruitment relationship needs to be propagated through into the pdf of  $F_{MSY}$  and other quantities of interest (i.e., estimate  $h$  with a justifiable prior).

For the new single-species stock assessment model:

- Perform a detailed historical analysis of the length/age composition of the catch in relationship to possible explanatory variables to enable the fishery to be split into multiple components for the purposes of stock assessment. The minimum split will be into A and B seasons with a processor and catcher fleet to mimic the reality of the fishery.
- The information that is known about the survey  $q_s$  should be included in the stock assessment model through informed priors.
- The objective function, for a Bayesian stock assessment, can and should be derived purely from likelihood components (generated by statistical assumptions with regard to data), prior distributions, and an occasional penalty function (if absolutely necessary).

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## **Appendix 1: Bibliography of supplied material**

### **Documents related to the Terms of Reference for the EBS pollock CIE review**

EBS Pollock 2015 assessment (p. 53–152 in the 2015 SAFE report)

Appendix 1.1: Stock structure of EBS pollock presented in September 2015

Overview: Harvest Specification and Inseason Management (draft document, 5 p.)

### **Other background documents**

Dec 2015 SSC Minutes on EBS pollock (Starts on page 9)

Nov 2015 Plan Team Minutes on EBS pollock (but see their Introduction to SAFE report for their summary)

SAFE report including other chapters/stocks

### *2015 Recruitment Processes CIE review*

Drinkwater, K.F. 2015. Center for Independent Experts (CIE) Independent Peer Review for the Recruitment Processes Alliance Research in the Southeastern Bering Sea. 39 p.

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Simmonds, E.J. 2015. CIE Independent Peer Review Report of: Fisheries Recruitment Processes Applied Research in Support of Ecosystem Based Fishery Management of the Bering Sea Ecosystem. 45 p.

Smith, T. 2015. Center for Independent Experts (CIE) Independent Peer Review of Recruitment Processes Alliance Research in the Southeastern Bering Sea. 34 p.

### **Management, observer program, etc**

Alaska Fisheries Science Center (AFSC). 2016. Observer Sampling Manual. Fisheries Monitoring and Analysis Division, North Pacific Groundfish Observer Program. AFSC, 7600 Sand Point Way N.E., Seattle, Washington, 98115. 609 p.

Cahalan, J., J. Gasper, and J. Mondragon. 2014. Catch sampling and estimation in the federal groundfish fisheries off Alaska, 2015 edition. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-286, 46 p.

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### Survey documents

- Honkalehto, T., and A. McCarthy. 2015. Results of the acoustic-trawl survey of walleye pollock (*Gadus chalcogrammus*) on the U.S. and Russian Bering Sea Shelf in June - August 2014 (DY1407). AFSC Processed Rep. 2015-07, 63 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.
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- Smith, S.J. 2010. Report for the Center of Independent Experts on the Review Panel for Eastern Bering Sea Pollock Stock Assessment and Management Methods (June 28 to July 1, 2010). 18 p.
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## **Appendix 2: Statement of Work for Patrick Cordue**

### **External Independent Peer Review by the Center for Independent Experts**

#### **Assessment of the pollock stock in the Eastern Bering Sea**

**Scope of Work and CIE Process:** The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from [www.ciereviews.org](http://www.ciereviews.org).

**Project Description:** The annual assessments of the pollock stock in the EBS have used similar model configurations for a number of years now. Review is needed to identify areas where the assessment can be improved and aspects that would lead to best-practices for near term catch recommendations. The SSC has requested evaluation of environmental covariates for relative cohort strength, and temperature effects on survey catchability and/or selectivity. Other evaluations on the effect of alternative catch scenarios (i.e., if the catch was equal to the ABC) would be useful to help provide context to the current management practices (in which catches are in most years constrained by a 2 million t limit for all groundfish in the BSAI region). The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

**Requirements for CIE Reviewers:** Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of stock assessment methods in general, and preferably Stock Synthesis in particular. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

**Location of Peer Review:** Each CIE reviewer shall conduct an independent peer review during the panel review meeting *scheduled in Seattle, WA during May 16-19, 2016 (or one of the subsequent weeks)*.

**Statement of Tasks:** Each CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website:

<http://deemedexports.noaa.gov/>

[http://deemedexports.noaa.gov/compliance\\_access\\_control\\_procedures/noaa-foreign-national-registration-system.html](http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html)

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or online) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Assessment of the walleye pollock stock in the eastern Bering Sea (~100 p.), including a stock structure evaluation provided as an appendix)

CIE review of the recruitment processes group conducted June 2015

Comments on the final 2015 EBS pollock assessments by the Plan Team and SSC

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified

herein. **Modifications to the SoW and ToRs cannot be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

The review meeting will include three main parts:

1. A series of presentations with follow-up questions and discussions by CIE reviewers, to be chaired by an AFSC scientist.
2. Any real-time model runs and evaluations conducted in an informal workshop setting, as proposed by the CIE reviewers.
3. Initial report writing by the CIE reviewers, with opportunity for additional questions of the assessment author.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: Each CIE reviewer may assist the Chair of the panel review meeting with contributions to the Summary Report, based on the terms of reference of the review. Each CIE reviewer is not required to reach a consensus, and should provide a brief summary of the reviewer's views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

**Specific Tasks for CIE Reviewers:** The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

- 1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
- 2) Participate during the panel review meeting ***scheduled at the Alaska Fisheries Science Center in Seattle, WA during May 16-19, 2016.***
- 3) Participate at the peer review meeting ***tentatively scheduled at the Alaska Fisheries Science Center in Seattle, WA during May 16-19, 2016*** as specified herein, and conduct an independent peer review in accordance with the ToRs (**Annex 2**).
- 4) No later than **June 3, 2016**, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Dr.

Manoj Shivilani, CIE Lead Coordinator, via email to mshivilani@ntvifederal.net, and CIE Regional Coordinator, via email to Dr. David Die ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

**Schedule of Milestones and Deliverables:** CIE shall complete the tasks and deliverables described in this SoW in accordance with the following *tentative* schedule.

<i>April 4, 2016</i>	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
<i>April 25, 2016</i>	NMFS Project Contact sends the CIE Reviewers the pre-review documents
<b><i>May 16-19, 2016</i></b>	Each reviewer participates and conducts an independent peer review during the panel review meeting
<i>June 6, 2016</i>	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
<i>June 20, 2016</i>	CIE submits CIE independent peer review reports to the COTR
<i>June 27, 2016</i>	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

**Modifications to the Statement of Work:** This ‘Time and Materials’ task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council’s SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

**Acceptance of Deliverables:** Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables



(CIE independent peer review reports) to the COTR (William Michaels, via [William.Michaels@noaa.gov](mailto:William.Michaels@noaa.gov)).

**Applicable Performance Standards:** The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:

- (1) The CIE report shall be completed with the format and content in accordance with **Annex 1**,
- (2) The CIE report shall address each ToR as specified in **Annex 2**,
- (3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

**Distribution of Approved Deliverables:** Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in \*.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

**Support Personnel:**

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NMFS Office of Science and Technology  
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**Key Personnel:**

NMFS Project Contact:

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Seattle WA 98115  
[Jim.ianelli@noaa.gov](mailto:Jim.ianelli@noaa.gov)

## **Annex 1: Format and Contents of CIE Independent Peer Review Report**

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.
2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.
  - a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.
  - b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.
  - c. Reviewers should elaborate on any points raised in the Summary Report that they feel might require further clarification.
  - d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.
  - e. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.
3. The reviewer report shall include the following appendices:
  - Appendix 1: Bibliography of materials provided for review
  - Appendix 2: A copy of the CIE Statement of Work
  - Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

## **Annex 2: Terms of Reference for the Peer Review**

### **Assessment of Walleye Pollock in the Eastern Bering Sea**

1. Evaluation, findings, and recommendations on quality of input data and methods used to process them for inclusion in the assessment. In particular:
  - Is the use of the index of acoustic backscatter from opportunistic (AVO) used appropriately?
  - Is modeling observed numbers from surveys appropriate?
  - How should data on mean body mass at age be best used for model projections?
  - How should the various data sets be weighted?
2. Evaluate and provide recommendations on model structure, assumptions, and estimation procedures used to assess stock status and condition. In particular:
  - Are the selectivity approaches used for surveys and fishery appropriate?
  - How should trans-boundary aspects of the resource be handled?
  - What constraints, if any, should be placed on survey catchability?
  - How should model projection alternatives be evaluated/presented?
  - Anything else on which the reviewers care to comment.
3. Evaluate and provide recommendations on harvest recommendations provided by the NPFMC Tier system in the context of the 2,000,000 t BSAI cap and realized management recommendations
4. Evaluate the extent that ecosystem data are presently included in the assessment and recommend how and where improvements can be made.

### Annex 3: Tentative Agenda

## CIE Review of the Eastern Bering Sea Walleye Pollock stock assessment

Alaska Fisheries Science Center  
7600 Sand Point Way NE, Seattle, WA 98115  
May 16-19, 2016  
Building 4; Room 2143 (or TBD)

**Review panel Chair/facilitator:** Anne Hollowed ([Anne.Hollowed@noaa.gov](mailto:Anne.Hollowed@noaa.gov))

**Lead assessment author:** Jim Ianelli ([Jim.Ianelli@noaa.gov](mailto:Jim.Ianelli@noaa.gov))

**Security and check-in:** Jim Ianelli

*Sessions will run from 9 a.m. to 5 p.m. each day, with time for lunch and morning and afternoon breaks. Discussion will be open to everyone, with priority given to the panel and senior assessment author.*

#### Monday, May 16

##### Preliminaries:

0900 Introductions and adoption of agenda	Chair
Data sources (current and potential):	
0910 Overview of data types used in the assessments	Jim I.
0920 Catch accounting system and in-season management	AKRO SF Division
0950 Observer program	Observer program
1020 Break	
1030 EBS trawl survey	Stan Kotwicki
1115 Acoustic trawl survey	Chris Wilson
1200 Lunch	
1300 Age determination	Tom Helser
1330 Age composition and mean-weight-at-age data	Jim I.
Assessment models:	
1400 Assessment details	Jim I.
1500 Break	
1510 Management background and issues (ToR 3)	Diana Stram (NPFMC)
1610 Ecosystem application in assessment (ToR 4)	TBD
1640 Discussion	Panel

#### Tuesday, May 17

0900 Assessment model review	Jim
1000 Topics as needed, discussion and model clarifications	
1300 Presentation of model updates, further requests and discussions	
1700 Adjourn	

**Wednesday, May 18**

Review of models assigned the previous day

Discussion, real-time model runs

Assignments for models to be presented the following day

**Thursday, May 19**

Review of models

Discussion, real-time model runs

Report writing (time permitting)

### Appendix 3: Panel membership and meeting participants

Name	Organization	e-mail
Stan Kotwicki	NMFS – AFSC	Stan.Kotwicki@noaa.gov
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